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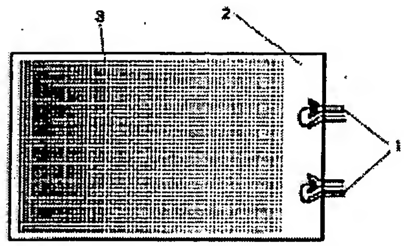
(54) [Title of Invention] Planar Light Source

(57) [Summary]

[Purpose] To realize a planar light source which could emit white light employing blue light emitting diodes, and to provide a planar light source from which a uniform white light emission can be observed.

[Constitution] Light emitting diodes are optically connected to an edge surface of a transparent optical waveguide. On one primary surface of the above-mentioned optical waveguide, there is a scattering fluorescent layer which is prepared by applying a phosphor which emits fluorescence when it is excited by the emission from the above-mentioned blue light emitting diodes and white powder which scatters the fluorescence in a state in which both materials are mixed. The above-mentioned scattering fluorescent layer converts the wavelength of the emission from the

above-mentioned blue light emitting diodes.



[What is Claimed is:]

[Claim 1] A planar light source, wherein blue light emitting diodes are optically connected to at least one portion of an edge surface of a transparent optical waveguide; further. on one primary surface of the aforementioned optical waveguide, there is a scattering fluorescent layer which is prepared by applying a phosphor which emits fluorescence when it is excited by the emission from the aforementioned blue light emitting diodes and white powder which scatters the fluorescence in a state in which both phosphor and white powder are mixed; the aforementioned scattering fluorescent layer converts the wavelength of the emission from the aforementioned blue light emitting diodes; and the emission is observed from a primary surface of the optical waveguide opposite to the aforementioned scattering fluorescent layer.

[Claim 2] The planar light source according to Claim 1, wherein the aforementioned blue light emitting diodes have a primary emission wavelength which is shorter than 500nm and an emission power of 500 μW or more.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention is related to a planar light source which is utilized for a backlight of display, illuminated switch and the like. In particular, it relates to a planar light source which is suitable for employing for a backlight of liquid crystal display.

[0002]

[Conventional Technologies] In general, EL and a cold cathode tube, for example, are employed as a planar light source for a backlight of liquid crystal display which is utilized in a laptop or word processor. EL itself is a planar light source and a cold cathode tube functions as a planar light source with a diffusing plate. At present, most color of such a backlight is white.

[0003] On the other hand, light emitting diodes (hereinafter referred to as LED's) are also employed as a light source for a backlight in some cases. Conventionally, however, when LED's are employed to obtain a white emission, the emission power of blue LED is only a few tens of μW and therefore, for realizing a white emission using red and green

LED's in addition, there are disadvantages in that it is difficult to match the properties of LED's for each color and that color variations are large. Moreover, even if LED's for the three primary colors gathered and arranged geometrically on the same plane, these LED's as a backlight are seen at a closer distance and recognized. Therefore, it is also impossible to create an uniform white light source. Accordingly, under the current circumstances, a different planar light source is employed for a planar light source: a cold cathode tube is utilized for large sizes and EL is utilized for small and mid sizes. A white-light emitting backlight using LED's is hardly known.

[0004] Moreover, as a white or monochrome light source, there are attempts to surround a blue LED chip with a resin which contains a phosphor for color conversion. The area around the chip is exposed to a radiation stronger than the sun light and therefore, deterioration of the phosphor becomes an issue. It becomes significant especially in organic fluorescent pigment. Furthermore, with an ionic organic pigment, an electrophoresis migration occurs near the chip under a DC electric field and there is a possibility that the color tone changes. Besides, conventional blue LED's do not posses enough power for color conversion with a phosphor and can not be put into practical use even with color conversion.

[0005]
[Issues to be Resolved by the Invention] The present invention was conceived to solve these disadvantages. Its purpose is to provide a planar light source from which a uniform white emission can be observed, along with realizing a planar light source which is able to emit white light utilizing LED's and which can be mainly used for a backlight, and further, to provide a planar light source which can emit light with any color other than white and utilize it in various switches, taking advantage of LED's reliability.

[0006]
[Means to Resolve the Issues] In a planar light source of the present invention, blue light emitting diodes are optically connected to at least one portion of an edge surface of a transparent optical waveguide; further. on one primary surface of the aforementioned optical waveguide, there is a scattering fluorescent layer (hereinafter, the primary surface on the side of scattering fluorescent layer is referred to as the second primary surface) which is prepared by applying a phosphor which emits fluorescence when it is excited by the emission from the aforementioned blue light emitting diodes and white powder which scatters the fluorescence in a state in which both phosphor and white powder are mixed;

the aforementioned scattering fluorescent layer converts the wavelength of the emission from the aforementioned blue light emitting diodes; and the emission is observed from a primary surface (hereinafter, the primary surface on the side to observe the emission is referred to as the first primary surface) of the optical waveguide opposite to the aforementioned scattering fluorescent layer.

[0007] Figure 1 is a top view when an optical waveguide 2 of a planar light source of the present invention is viewed from the side of a scattering fluorescent layer 3. Optical waveguide 2 is made of a transparent material such as acrylic or glass, and blue LED's 1 are embedded on an edge surface of optical waveguide 2, thereby optically connecting blue LED's 1 to optical waveguide 2. In the present invention, optically connecting blue LED's 1 to the edge of optical waveguide 2 means that, simply put, emissions from blue LED's are introduced into the edge of optical waveguide 2. For instance, as illustrated in the figure, such an optical connection can be achieved, as a matter of course, by embedding blue LED's 1 , but also by guiding emissions of blue LED's through optical fibers and the like to the edge of optical waveguide 2.

[0008] Next, an ink in which a phosphor and a white pigment are mixed is applied to form scattering fluorescent layer 3 so that a desired color can be observed. The phosphor converts the wavelength of the emission from blue LED's 1, and at the same time, the white pigment scatters the fluorescence into optical waveguide 2. In particular, in Figure1, aforementioned scattering fluorescent layer 3 is made of dots which are arranged in a pattern in which, for the purpose of keeping the surface brightness on the first primary surface side constant, the area covered by scattering fluorescent layer 3 per unit area of the second primary surface is smaller in a region closer to LED's 1. Furthermore, the area covered by scattering fluorescent layer 3 near the edge farthest from LED's 1 on second primary surface is slightly smaller than the maximum area. Herein squares in Figure 1 denote the pattern of scattering fluorescent layer 3. In Figure 1, two blue LED's are arranged on one edge. However, if an optical waveguide is rectangular, it goes without saying that LED's can be connected to all four edges and the number of LED's is not to be limited. Moreover, depending on the arrangement of LED's, the form and conditions of application of a scattering fluorescent layer can be changed accordingly in order for the emission observed from the first primary surface to be uniform.

[0009]

[Operation of the Invention] Figure 2 is a schematic cross-sectional view of a planar light source of the present invention when the planar light source is implemented, for example, as a backlight of liquid crystal panel. On the second primary surface side of the planar light source illustrated in Figure 1, a reflection plate is provided in which a scattering reflective layer 6 made of a material such as barium titanate, titanium oxide, or aluminum oxide and the like as an example, and a base 7 which consist of A1 as an example are stacked. A optical diffusion plate 5 on whose surface bumps are formed is placed on the first primary surface side. This constitution is not especially different from that of a backlight which employs a cold cathode tune as its light source.

[0010] First, as arrows in Figure 2 illustrate, light emitted from blue LED's 1 is partially radiated out of optical waveguide 2 near the chips, but most of the light travels inside of optical waveguide 2 as it repeats total reflections, and reaches edge surfaces. The light reaching the edge surfaces is reflected from reflection layer 4 which is formed on all edge surfaces and repeat total reflections. At this time, a part of the light is scattered by scattering fluorescent layer 3 formed on the second primary surface of optical waveguide 2. A part of the light is absorbed by the phosphor, its wavelength is converted at the same time, and then the light is radiated. The emission color observed from the first primary surface of optical waveguide 2 is a combination of all those lights. For example, from a planar light source with a scattering fluorescent layer 3 consisting of a fluorescent pigment for orange and a white pigment, an emission color from blue LED's will be observed as white, according to the aforementioned operation. Moreover, any color tone can be prepared by changing the type of a phosphor and a mixing ratio with a white pigment. Especially in the present invention, the emission wavelength of one blue LED needs to have its main emission peak at a wavelength shorter than 500nm, and its main emission power needs to be 200μW or more. Preferably, its power should be 300 μW or more. Because it is difficult to create all colors if the emission wavelength is 500nm or longer, and it tends to be difficult to obtain a light source with a sufficiently bright, uniform planar emission if its emission power is less than 200 μW, even if the number of blue LED's is increased which are optically connected to edge surfaces of the optical waveguide,

[0011]

[Embodiments]

[Example 1] On one side of an acrylic plate with a thickness of approximately 2mm, a scattering fluorescent layer 3 was formed in a dot pattern as illustrated in Figure 1 using

a screen printing method. An equal amount of a fluorescent pigment for red, FA-001 manufactured by SINLOIHI Chemical Co., LTD., and a fluorescent pigment for green, FA-005 manufactured by the same company were mixed to prepare a fluorescent pigment. The fluorescent pigment and powder made of barium titanate were mixed at a ratio of 1:5 by weight, then dispersed in an acrylic binder, and printed to form scattering fluorescent layer 3.

[0012] Next, the acryl plate on which the scattering fluorescent layer was formed in the manner as above was cut according to a desired pattern. All edge surfaces (surfaces along which the plate was cut) of the acrylic plates were polished. Then, a reflection layer 4 made of A1 was formed on the polished surfaces, thereby obtaining an optical waveguide 2 with scattering fluorescent layer 3.

[0013] Two holes were made on an edge surface of aforementioned optical waveguide 2. One blue LED made of gallium nitride related compound semiconductors with an emission wavelength of 480nm and an emission power of 1,200μW was embedded in each hole and thereby, a planar light source of the present invention was obtained. When the blue LED's on the planar light source were turned on at the same time, a slightly yellowish white nearly uniform planar emission was obtained from the emission observing side of the optical waveguide 2. Further, an optical diffusion plate 5 which was mat-processed was placed on the emission observing side, and a reflection plate in which a barium titanate layer 6 was applied on an A1 base 7 was placed on the side of scattering fluorescent layer 3 to prepare a light source for backlight. As a result, a completely uniform white emission was obtained from the side of optical diffusion plate 5. The brightness was 55cd/m^2.

[0014] [Example 2] An approximately equal amount of a fluorescent dye for yellow, LumogenF Yellow-083 manufactured by BASF corporate and a fluorescent dye for orange, Orange-240 manufactured by the same company, and dissolved in butyl carbitol acetate to prepare a fluorescent dye. The fluorescent dye and a white substance, barium titanate, were mixed at a weight ratio of 1 (dye): 200 by weight and formed into a scattering fluorescent layer 3. Other conditions were the same as in Example 1 and a planar light source of the present invention was made. An almost completely uniform planar emission was observed. Furthermore, when it was used as a light source for backlight, a completely uniform planar emission was observed.

[0015]

[Advantages of the Invention] As explained above, a planar light source of the present invention employs blue LED's, and has a scattering fluorescent layer containing a phosphor that can convert the wavelength of an emission from the blue LED's and white powder on one side of an optical waveguide, thereby enabling a planar light source utilizing LED's which excel in reliability. The white powder in scattering fluorescent layer, in addition, has effects to reflect and diffuse the light whose wavelength has been converted by the phosphor. Therefore, a smaller quantity of the phosphor needs to be consumed. Further, what provides additional advantage is that LED chips never come in direct contact with the phosphor. Hence, there is less deterioration on the phosphor and there will not be any change in color tone of the planar light source for a long time. Further, as for the color tone, any color tone including white can be provided by changing the phosphor and white powder, and/or the mixing ratio.

[0016] On the other hand, specifying that the emission power of blue LED's which are most preferably employed to excite a scattering fluorescent layer be 200μW or more enables a phosphor to efficiently covert the wavelength of the emission and a bright planar light source with a large area to be realized. Thus, a planar light source of the present application can be utilized not only as a light source for backlight, but also as a illuminated switch employing a phosphor and the like.

[Brief Description of Figures]

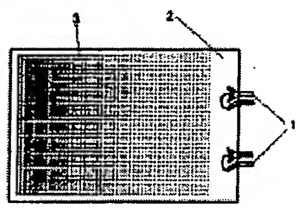
[Figure 1] A top view when an optical waveguide 2 of a planar light source of an example of the present invention is viewed from the side of a scattering fluorescent layer 3.

[Figure 2] A schematic cross-sectional view when a planar light source of an example of the present invention was implemented as a backlight.

[Explanation of Numeral Labels]

1	Blue LED		
2	Optical waveguide	5	Optical diffusion plate
3	Scattering fluorescent layer	6	Scattering reflective layer
4	Reflection plate	7	A1 base

[Figure 1]



[Figure 2]